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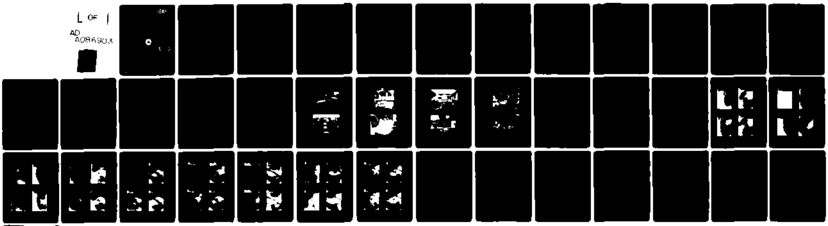

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FUEL FIRE HAZARD PENETRATION INTO A MODEL FUSELAGE AS A FUNCTION OF CIRCUMFERENTIAL DOOR LOCATION AND FUEL BED HEIGHT

Thor I. Eklund
Joseph A. Wright

DEPARTMENT OF TRANSPORTATION • UNITED STATES OF AMERICA

NAFEC REPORT

MAY 1980

Prepared for
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National Aviation Facilities Experimental Center
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16. Abstract

The purpose of this test program is to devise and evaluate techniques for modeling aircraft cabin fires. A rotatable model fuselage section, 3 feet in diameter and 10 feet long, was placed adjacent to a height-adjustable 4-foot-square pan of JP-4 for fire tests in a quiescent indoor environment. One door on the fuselage side was opened and exposed to the pool fire, while another door in the end of the fuselage remained either opened or closed during the fire test to create natural ventilation effects in the interior. Rotation of the fuselage and raising or lowering the fuel pan provided variations in the resultant interior hazard and led to the following four conclusions: (1) the opening of an additional door always decreases the measured hazard from an external pool fire covering an open doorway in a windless environment; (2) for the specific rotational positions tested on the model, the hazard to the interior from the external fire is increased as the fire base is lowered on the side of the fuselage; (3) when the fuel fire base is maintained at a fixed height with respect to the fuselage, the hazard peaks at the position where actual doorways are installed; and (4) noted discrepancies among past tests with a variety of fuselages can be explained by accounting for differences in door location on the fuselage perimeter and height of the fuel bed.

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METRIC CONVERSION FACTORS

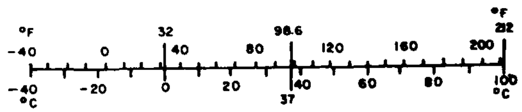
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

The assistance of Messrs. Franklin Fann and William Markland in performing these tests is acknowledged. Mr. Joseph Cox performed the photographic documentation.

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INTRODUCTION

PURPOSE.

The purpose of this test program is to devise and evaluate techniques for modeling aircraft cabin fires. The end product will be more economical methods of aircraft fire testing as well as more comprehensive understanding of the dynamics of hazard development during a postcrash cabin fire. The motivation for the tests described in this document was to investigate discrepancies between modeling and full-scale fire test results as possibly being caused by fuselage orientation and height of open doorways above the pool fire.

BACKGROUND.

The current cabin fire safety program at the National Aviation Facilities Experimental Center (NAFEC) contains the following three major elements: full-scale fire tests in a simulated wide-body aircraft (reference 1); fire-modeling tests (reference 2); and broad laboratory programs in smoke, flammability, and toxicity (reference 3). The fire-modeling tests are the most recent addition to the program, and the modeling tests are conducted along with full-scale tests both to preview the test variables and to develop a broader base of data.

The first series of model tests (reference 4) led to a determination of radiative flux to the cabin interior from an external fuel fire and resulted in redesign of the pool fires used in NAFEC full-scale tests (reference 1).

The second phase of the modeling tests (partly described in reference 5) involved the use of a 26.5-foot-long 1/4-scale simulated fuselage complete with six doors, a floor, and a ceiling. This phase of modeling concentrated on the effects of wind and door openings on hazard development within a fuselage from an external pool fire. The result was a clear exposition of the importance of door opening configurations and wind on hazard development. However, at this point the model tests were employing fire sizes up to twice the diameter of the fuselage, and the existing wide-body, full-scale facility was restricted to fire sizes of slightly more than half the fuselage diameter.

In order to validate the applicability of model test results to larger fires as well as to confirm the model predictions on the effects of doorways, a supplementary project was established whereby a surplus DC-7 fuselage was exposed to a 20-foot-square fuel fire (reference 6). The project generated full-scale information on the cabin hazards generated by a large fuel fire adjacent to full-size aircraft fuselage. The results of these tests agreed well with those of the model tests with one marked exception. In model tests conducted under zero-wind conditions, opening even one additional doorway prevented entirely the accumulation of heat and smoke in the cabin from the door exposed to an external pool fire. In the DC-7 project, however, heat and smoke built up in the cabin during the zero-wind tests regardless of the number of additional doors opened.

At least three hypotheses have been advanced for this anomaly between the model and the DC-7. First, a simple geometric scaling of the fire scenario may not effectively reproduce the full-scale phenomena in all respects. Second, a possibility exists that the anomaly is caused by the different fire sources. For the model, the fuel fire was contained in a steel tray suspended approximately 2 feet above the ground. In the DC-7 project, the fuel fire was contained in a concrete basin at the ground level. This second hypothesis, if true, also has a bearing on the wide-body (C-133) project, which also employed raised fire pans. Finally, the fire penetration may be affected by the circumferential position of the doorway. The DC-7 doorway is approximately centered with respect to the top and bottom of the fuselage, while the model had a doorway placed higher on the fuselage side. The comparisons are photographically shown in figure 1.

EXPERIMENTAL OBJECTIVE.

The experimental objective of these tests was to determine the effects of the following parameters on hazard development within a fuselage from an external pool fire: (1) circumferential position of the door opened to the fire, (2) additional door openings in a quiescent environment, and (3) height of the door above the fire. More specifically, the test objective was to determine the cause of the aforementioned difference in results between the earlier documented model tests and subsequent full-scale investigations.

DISCUSSION

TEST CONFIGURATION.

The tests were performed in a warehouse-type building, 102 feet long and 39 feet wide. The building side walls were 20 feet high, and a 26-foot-high peak ran the length of the building. All test fires were positioned under the peak and 55 feet from the front of the building.

The fire scenario consists of an intact fuselage with an external fuel fire adjacent to a doorway opening and possibly another opening away from the fire.

The tests involved positioning a model fuselage section against a fuel-filled pan that would serve as the fire bed. Both the pan and the model could be raised and lowered with respect to each other, and the model could be rotated along its centerline or longitudinal axis. In this manner, a doorway cut in its side could be varied as to height above the fire base and to circumferential position on the fuselage.

The model fuselage section (hereafter designated as the model) was a close-ended duct of 10-foot length and 3-foot diameter. The model was fabricated from shaped and welded 0.062-inch mild steel sheet, reinforced with 2- by 0.187-inch bands. The end flanges were made of 0.187-inch mild steel sheet. An 8- by 16-inch door was cut into the side of the model midway between the flanged ends. This door was geometrically scaled to the door in the C-133 fuselage (reference 1).

Each end of the model had a cover fabricated in such a way that the cover could be detached while the model was rotated and thus maintain its vertical orientation. One cover held a large observation window through which the interior could be illuminated, viewed, and photographed. The other cover had a removable 10- by 12-inch glass window in its center. The removal of this window would simulate the opening of an additional door in a longer fuselage. Figures 2a and 2b show overall views of the test configuration, while figures 3a and 3b show test photographs with the two end covers visible.

The fuel pan was 4-feet square and was immersed in a 4.5- by 5.5-foot water-filled pan to prevent warping of the metal. The water-filled pan rested on a chassis made of angle iron, and the assembly was mounted on wheels for easy movement. The support points between the chassis and water pan were four scissor jacks. These jacks allowed leveling of the fuel pan and height adjustment with respect to the model.

Provisions for the model to be rotated and raised with respect to the fuel pan allowed a range of potential fire scenarios to be duplicated. Due to uncertainty of terrain as well as final fuselage orientation following a crash, numerous possible orientations of a fuselage with respect to a fire can be expected. For instance, collapse of the landing gear on one side of the aircraft would cause the fuselage and, consequently, the door angle to be oriented towards one side with a fire on the ground. Crash landings on unpaved areas where landing gear are sheared off can result in a configuration where the fire bed is relatively close to the bottom of a door or fuselage break.

INSTRUMENTATION.

The instrumentation for the test series consisted of temperature and photographic measurements. Three chromel/alumel thermocouples were mounted 1 inch below the top of the duct on a support bar. One of these was at the model center, and the other two were 28 inches from the model ends. Since the support bar was attached to the end covers, the thermocouples could be maintained at the ceiling when the model was rotated. A fourth thermocouple was mounted over the fuel pan to serve as an event marker when the fire was started. All four thermocouples monitored test conditions at approximate 2-second intervals. An Esterline Angus Model D2020 thermocouple recorder was used for data collection.

The major photographic documentation was accomplished by a motorized 35-millimeter camera with frame sequencing every 2 seconds during the test. The camera lens was positioned on the model centerline and outside the end cover with the viewing window. The camera had a split-screen viewing capability and clock. Therefore, every frame showed the model interior along with the time, frame number, and test number. While the ceiling thermocouples measured interior temperature increases caused by fire penetration through the model doorway, the photographs provided a qualitative measure of the smoke buildup during the test.

TEST DEVELOPMENT.

Three parameters were varied in the course of this test series. First, the relative height of the model fuselage was changed with respect to the fuel pan height. Second, the model was rotated on its longitudinal axis so that the side door was at different positions on the model circumference. Finally the end cover 10- by 12-inch window was either in place or removed. This led to a total of 18 configurations, and each configuration was tested in duplicate to prevent any spurious conclusions from being drawn. Figure 4 shows the nine configurations for varying the relative height of the model along with its rotation. Rotation was measured as circumferential distance moved in inches between the center (top to bottom) of the door (as rotated) and the horizontal plane through the center of the fuselage. Four rotational positions were tested, -8, 0, 8, and 16 inches. The height of the fire source was also varied in relation to the lateral extension of the fuselage center. There were three fire source positions, 0, 8, and 16 inches circumferential distance between the top of fuel pan and laterally extended fuselage centerline. The significant dimensions are further described in table 1. In all tests, the model door was centered with respect to the adjacent fires; i.e., the center of the door opening was aligned with the center of the fire pan.

The tests were run in a fully enclosed quiescent environment. All smoke accumulation in the test building during the test was exhausted at the end of the test. The instruments were controlled from a room adjacent to the test building.

In a typical test, all windows were cleaned of soot, all doors to the building were closed, and all equipment was checked. Four gallons of JP-4 in the fuel pan were ignited by a hand-held torch. The fire burned for 60 seconds, and then the remotely controlled Cardox® CO_2 system was activiated to extinguish the fire.

RESULTS

It should be noted that the temperature and smoke hazards in these tests differed from those experienced in the previously tested 1/4-scale model (references 2 and 5), primarily from two effects. The 1/4-scale model had flooring and ceiling, while the model in these tests did not. In addition, the long length-to-diameter ratio of the 1/4-scale model allowed more volume for dispersal of heat and smoke entering the doorway. Nevertheless, this simplified 3-foot diameter fuselage was adequate for determining generalized effects of fuselage orientation.

Table 2 shows the type hazard at 40 and 60 seconds into the tests as noted by averaging the outputs of the two thermocouples closest to the model end covers. Also presented are comments developed from visual observations through the viewing window. Figures 5 through 13 show the corresponding

interior photographs taken at 40 and 60 seconds into the test. Since the motorized camera was sequenced every 2 seconds, the frame number 20 of a test is equivalent to the 40 second time, while frame number 30 is taken at 60 seconds into the test.

Except in some cases of total obscuration, the fire is visible through the door on the right-hand side of the photographs. The top two photographs on each figure represent a fuselage fire configuration with the end cover window closed. The bottom two photographs show the corresponding interior conditions for the case when the end cover window is open. In every case, opening the additional window results in less smoke. Also listed with each photograph is the corresponding ceiling temperature increase as noted in table 2.

Comparing the noted temperatures with the photographs indicate that there is no direct relationship between overall visibility and ceiling temperature in these tests. For instance, test 10 with a 40-second ceiling temperature increase of 219 Fahrenheit degrees (F°) shows less visibility than test 1 with a ceiling temperature increase of 283 F°. Rather, the relation between ceiling temperature and visibility is strongly affected by smoke stratification. For the closed end window cases, smoke stratification is clearly more pronounced when the door is higher up on the fuselage. This observation is generally true also for the cases when the end window is open, although only tests 7 and 12 show significant smoke accumulation in this case.

Figures 14 through 16 show plots of the 40- and 60-second ceiling temperature as a function of fuselage rotation for various fixed positions of the fire bed. Noted on these figures are the equivalent conditions found in the C-133 tests, the DC-7 tests, and the model tests. The general trend in evidence for these figures is that the hazard is worst when the center of the doorway is near the 90° position where 0° represents the top of the fuselage. (This is the location of actual doorways in most current transport aircraft.) The configuration equivalent to the DC-7 (tests 5 and 7) shows high temperature both when the end cover window is open and when it is closed. The C-133 and model configurations, on the other hand, show high temperatures when the end window is closed and low temperatures at 60 seconds when the end window is open.

These results conform to the past test experience for both modeling and full scale as documented in references 1, 5, and 6. The DC-7 had significant hazard development (reference 6) when additional ventilating doors were open as well as when they were closed. Earlier model tests had shown hazard buildup when the ventilating doors were closed, but not when they were open (reference 5). The C-133 has been tested only with the ventilating door open and consistently shows little hazard in a zero-wind environment. All these earlier configurations and relative hazards were duplicated with the tests described in this report, and the hazards were found to be controlled by fuselage rotation and fuel bed height.

The results in figure 15 predict that the C-133 would sustain significant heat and smoke from the external fuel fire if all doors other than the door facing the fire were closed.

Figures 17 through 19 show the temperature buildup at 40 and 60 seconds when the fuselage rotation is invariant but the fuel pan is adjusted in height relative to the fuselage. It is apparent that as the fire base is moved upwards on the side of the fuselage, the hazard development within the fuselage subsides. Thus, the DC-7, which had the fire base on the ground, generated a much more severe environment than the C-133 which had the fire base at the height of the door bottom.

Figure 20 shows a plot of temperature versus time for tests 22 and 24 to demonstrate the monotonic nature of the heat development. Even in test 24 which showed no smoke development at all, the ceiling temperatures would still rise noticeably during the test. This was due to two effects. First, the fire would radiate to the interior even when there was no documented flame penetration. Second, the model fuselage was not insulated. As a result, heat could be conducted efficiently through the wall and thereby heat the interior air. Nevertheless, these effects should have no effect on the conclusions developed.

CONCLUSIONS

The use of a 3-foot diameter model fuselage to evaluate the effects of fuselage rotation and fuel bed height on hazard development leads to four major conclusions:

1. The opening of an additional door always decreases the measured hazard from an external pool fire covering an open doorway in a windless environment.

2. For the specific rotational positions tested on the model, the hazard to the interior from the external fire is increased as the fire base is lowered on the side of the fuselage.

3. When the fuel fire base is maintained at a fixed height with respect to the fuselage, the potential hazard peaks at the position where actual doorways are installed in most current aircraft.

4. Noted discrepancies among past tests with a variety of fuselages can be explained by accounting for differences in door location on the fuselage circumference and height of the fuel bed relative to the fuselage.

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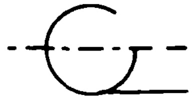
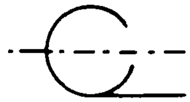
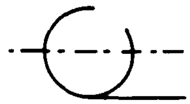
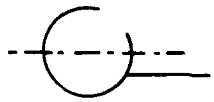
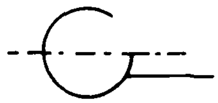
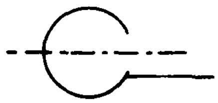
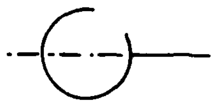
5. Eklund, T. I., Preliminary Evaluation of the Effects of Wind and Door Openings on Hazard Development within a Model Fuselage from an External Pool Fire, FAA/NAFEC, Report No. NA-79-1-LR, 1979.

6. Brown, L. J., Cabin Hazards from a Large External Fuel Fire Adjacent to an Aircraft Fuselage, FAA/NAFEC, Report No. FAA-RD-79-65, 1979.

TABLE 1. TEST DESCRIPTIONS

Test No. (Type)*	Circumferential** Distance Between Top of Fuel Pan and 90° Radius on Fuselage (C) Inches		Circumferential** Distance Between Center of Door and 90° Radius on Fuselage (D) Inches
1 (A)	16		8
3 (B)	16		8
5 (A)	16		0
7 (B)	16		0
10 (A)	16		-8
12 (B)	16		-8
14 (A)	16		16
16 (B)	16		16
18 (A)	8		16
20 (B)	8		16
22 (A)	8		8
24 (B)	8		8
26 (A)	8		0
28 (B)	8		0
30 (A)	0		8
32 (B)	0		8
34 (A)	0		16
36 (B)	0		16

* A = end door closed; B = end door open

** Reference figure 4.

TABLE 2. TEST CONDITIONS

Test No.	Averaged Temperature Increase (F°) 40 Seconds	60 Seconds	Visual Observations
1	283	380	Heavy smoke, flame penetration 6 inches deep
3	73	117	No smoke
5	331	591	Heavy smoke, flame penetration 8 inches deep
7	142	188	Heavy smoke, flame penetration 6 inches deep
10	219	304	Heavy smoke, fire licked along ceiling
12	102	137	Light smoke, slight flame penetration
14	155	199	Light smoke, some fire pulses through door
16	42	80	No smoke, no fire penetration
18	128	180	Light smoke, flames pulsed into doorway
20	37	114	No smoke, no flame penetration
22	244	348	Heavy smoke, flame penetration 8 inches deep
24	34	90	No smoke, no flame penetration
26	148	249	Heavy smoke, flame penetration 8 inches deep
28	41	112	No smoke, no flame penetration
30	42	151	Light smoke, little flame penetration
32	18	69	No smoke, no flame penetration
34	29	97	Light smoke, little flame penetration
36	12	58	No smoke, no flame penetration

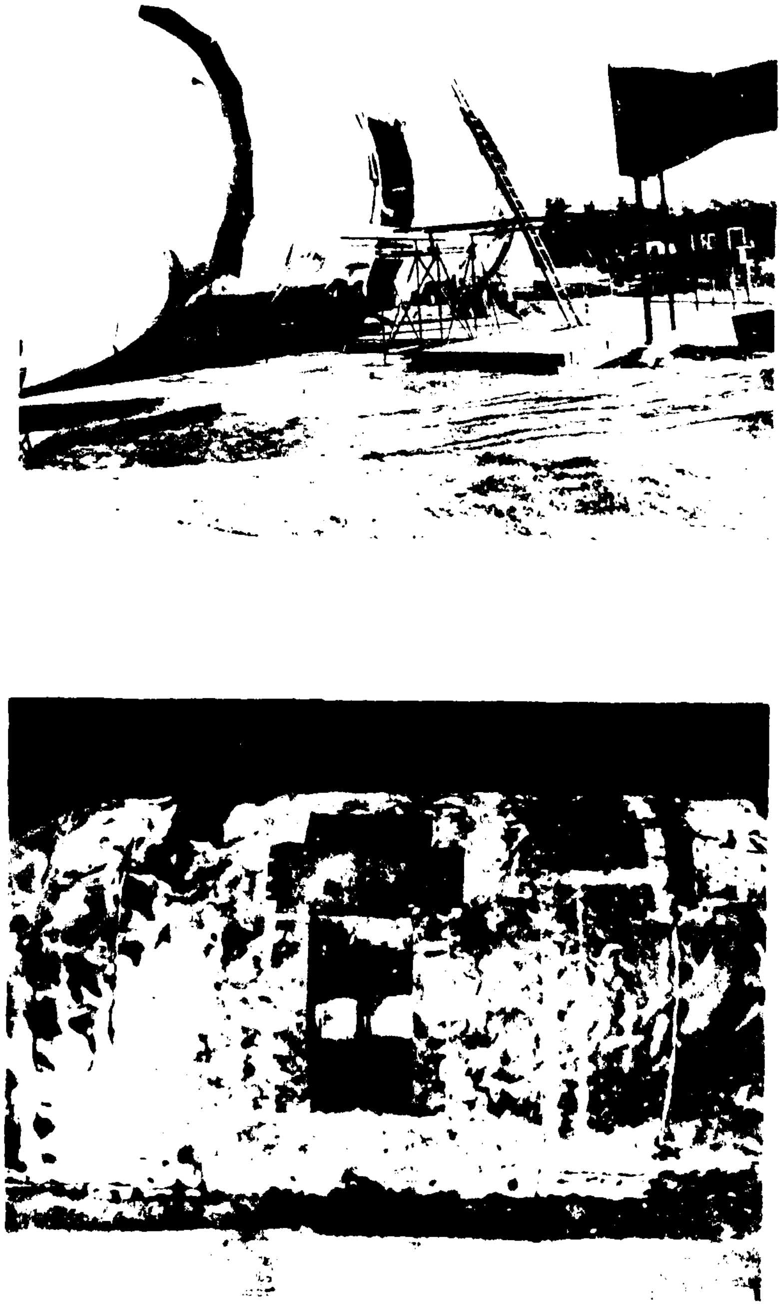


FIGURE 1. COMPARATIVE FULL-SCALE AND MODEL VIEWS (SHEET 1 of 2)

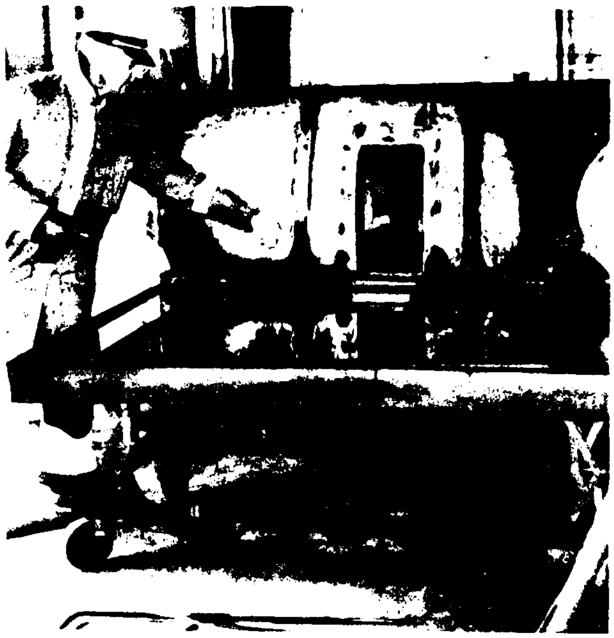


FIGURE 1. COMPARATIVE FULL-SCALE AND MODEL VIEWS (SHEET 2 of 2)

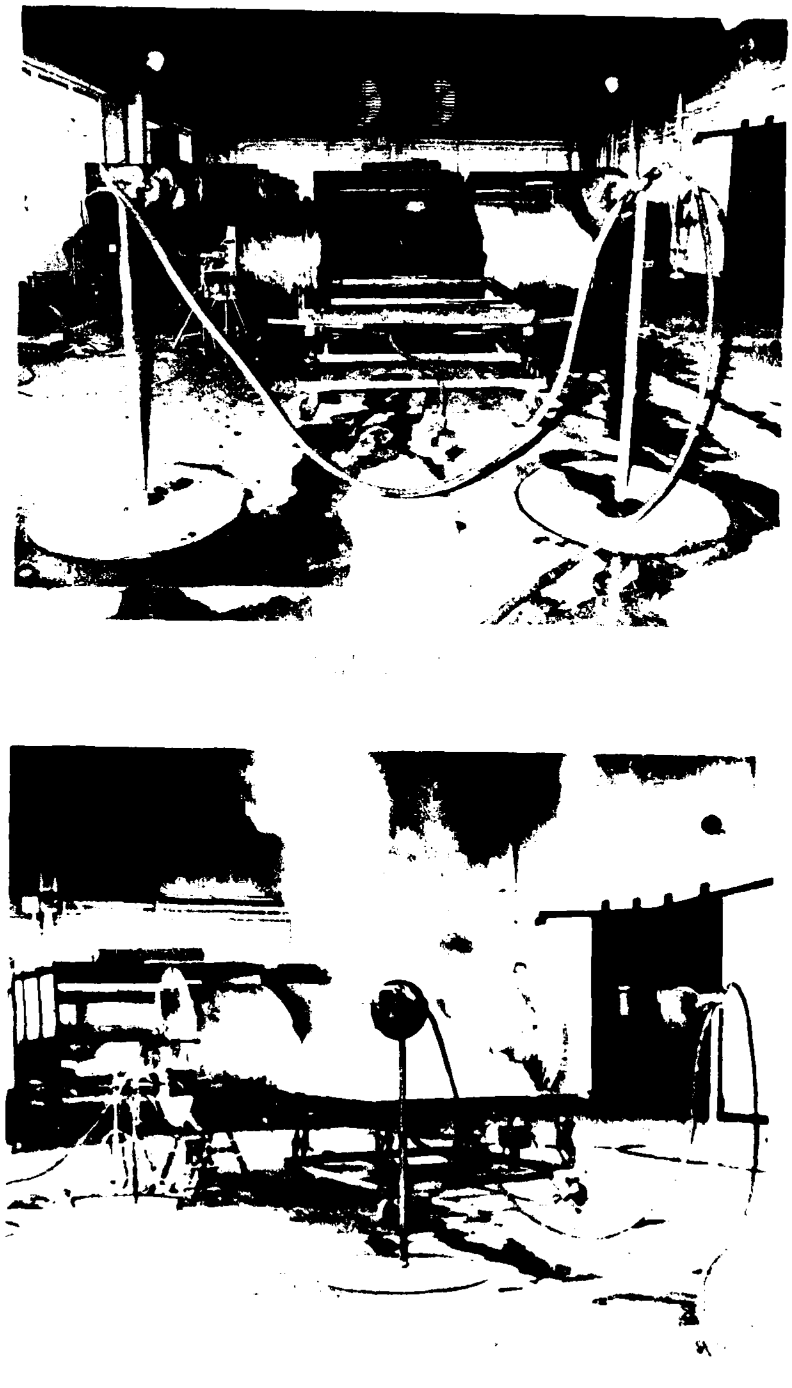


FIGURE 2. TEST BED FRONTAL VIEWS

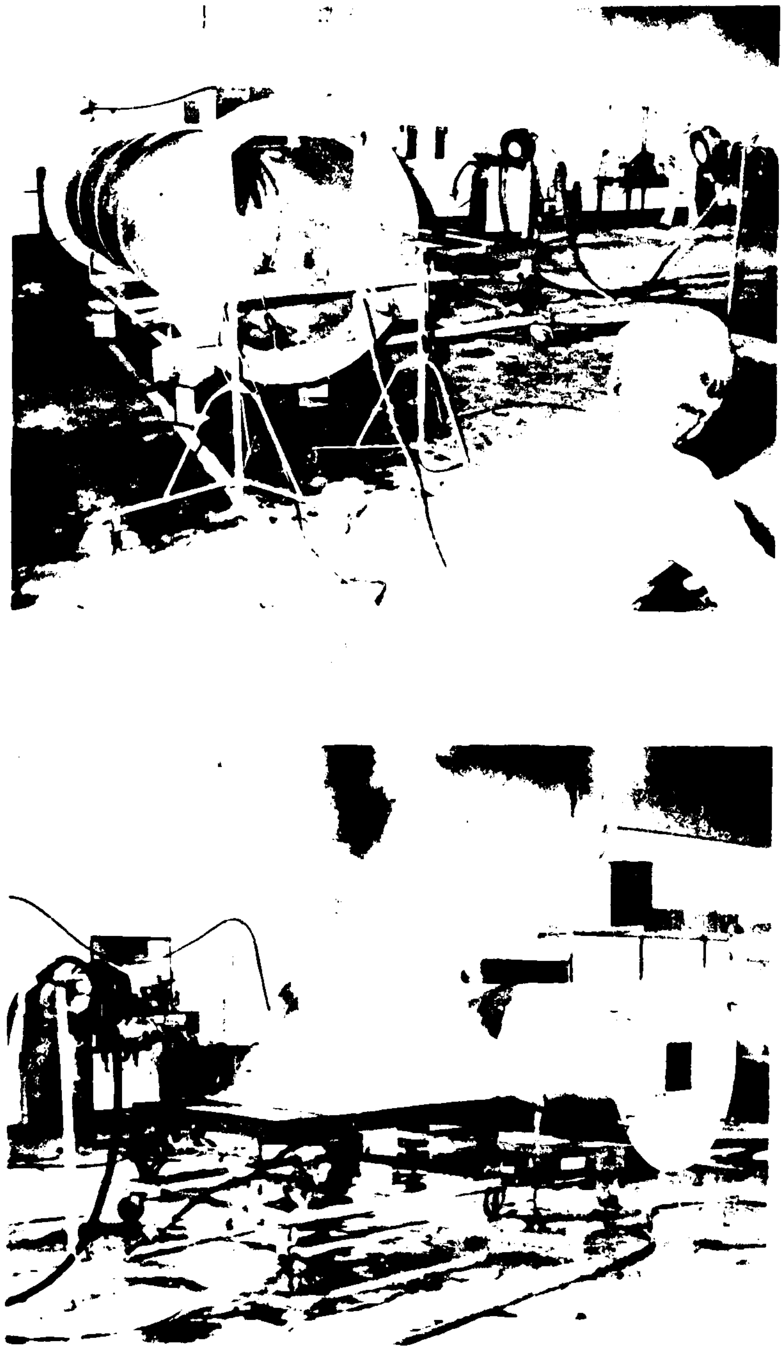


FIGURE 3. TEST BED SIDE VIEWS

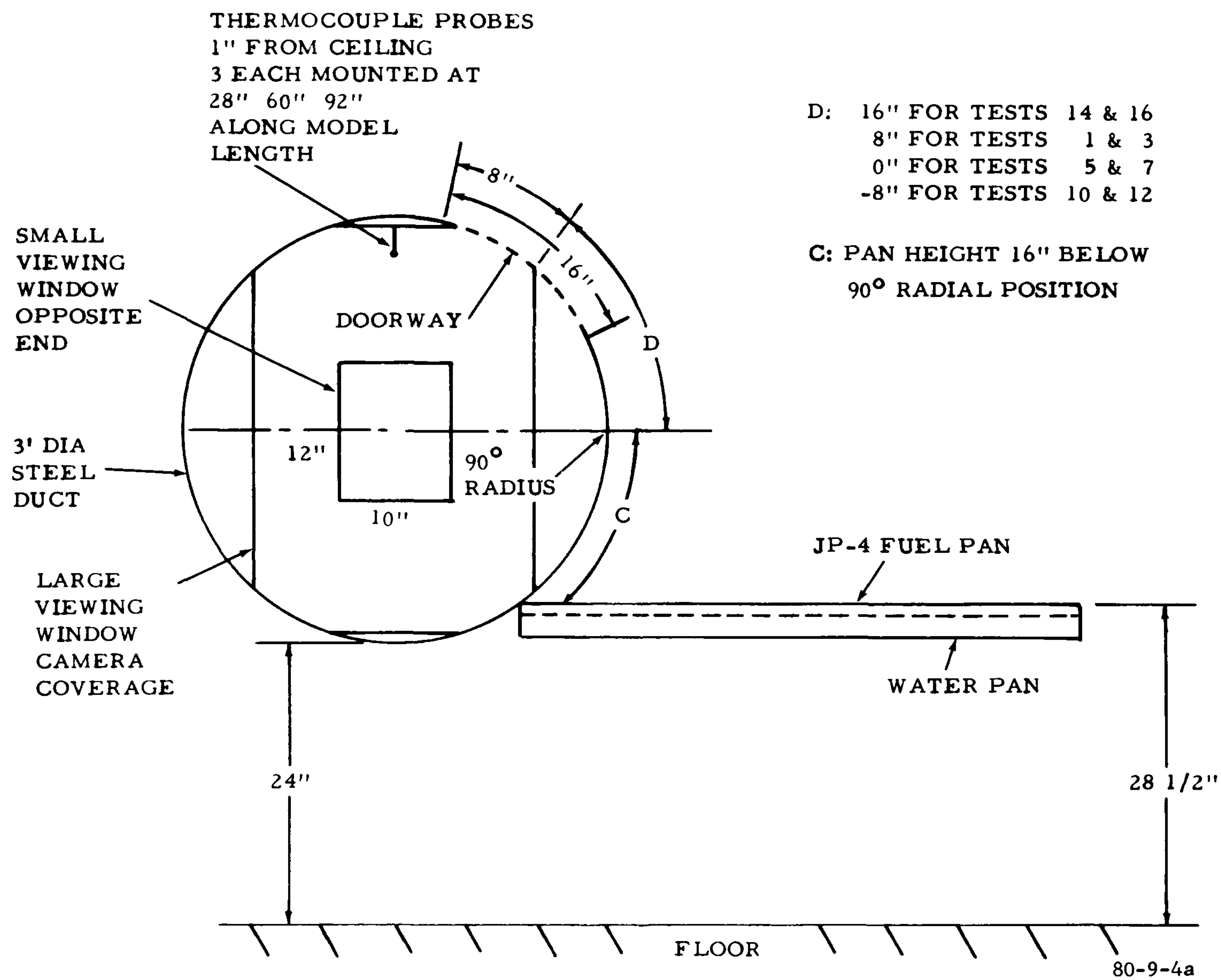


FIGURE 4. TEST CONFIGURATIONS (SHEET 1 OF 3)

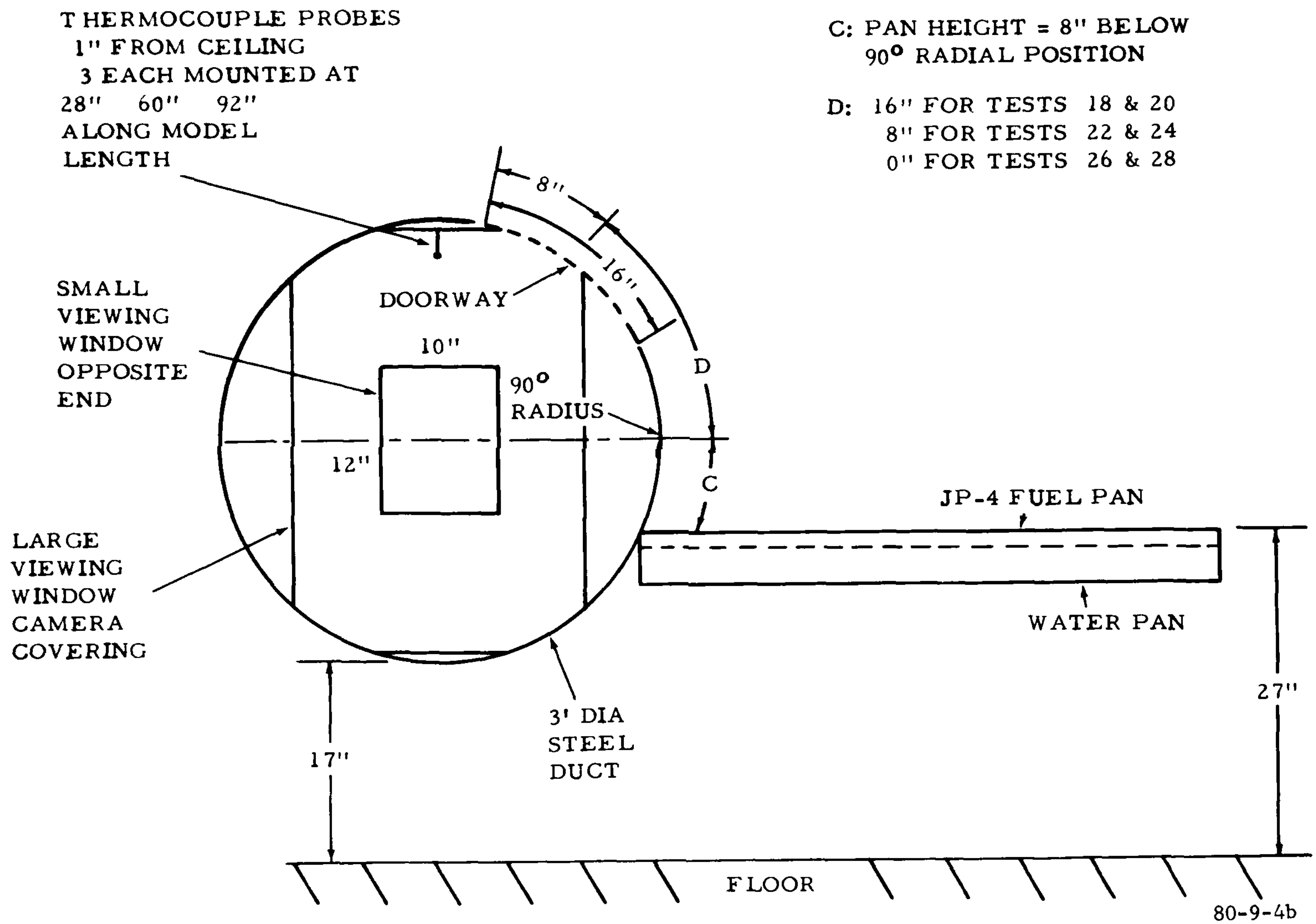
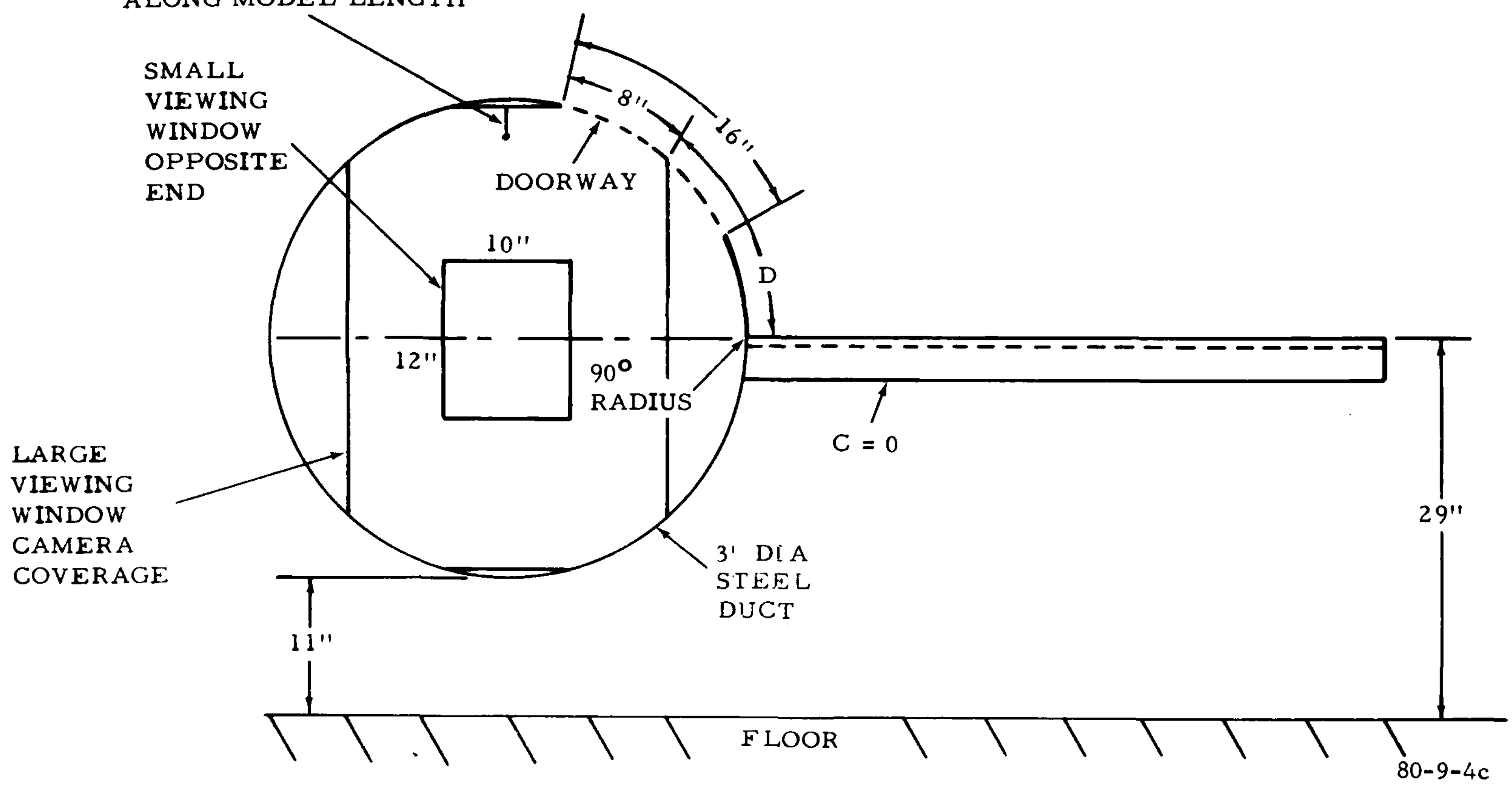


FIGURE 4. TEST CONFIGURATIONS (SHEET 2 OF 3)



C: PAN HEIGHT
AT 90° RADIAL
POSITION

D. 16" FOR TESTS 34 & 36
8" FOR TESTS 30 & 32

FIGURE 4. TEST CONFIGURATIONS (SHEET 3 OF 3)

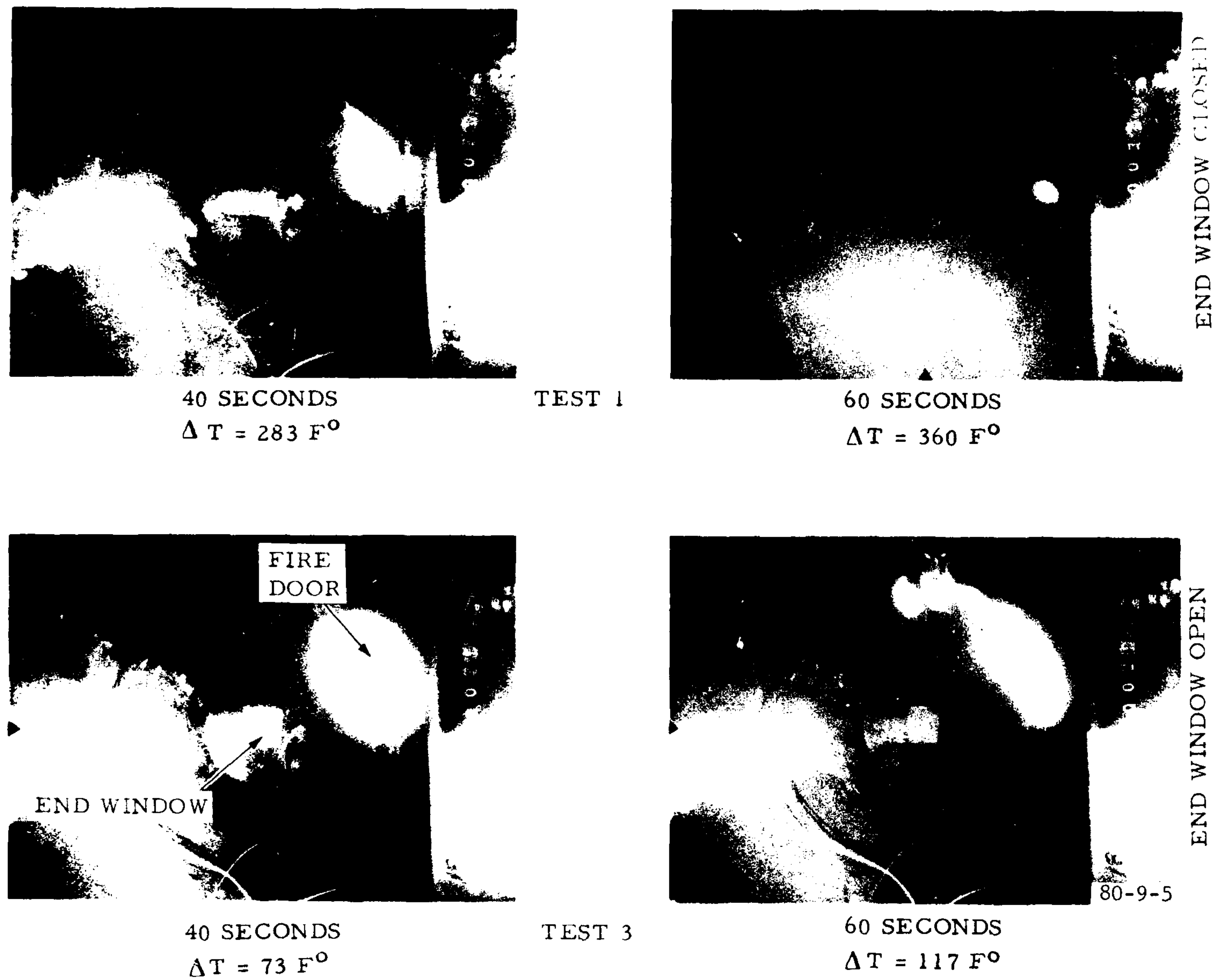
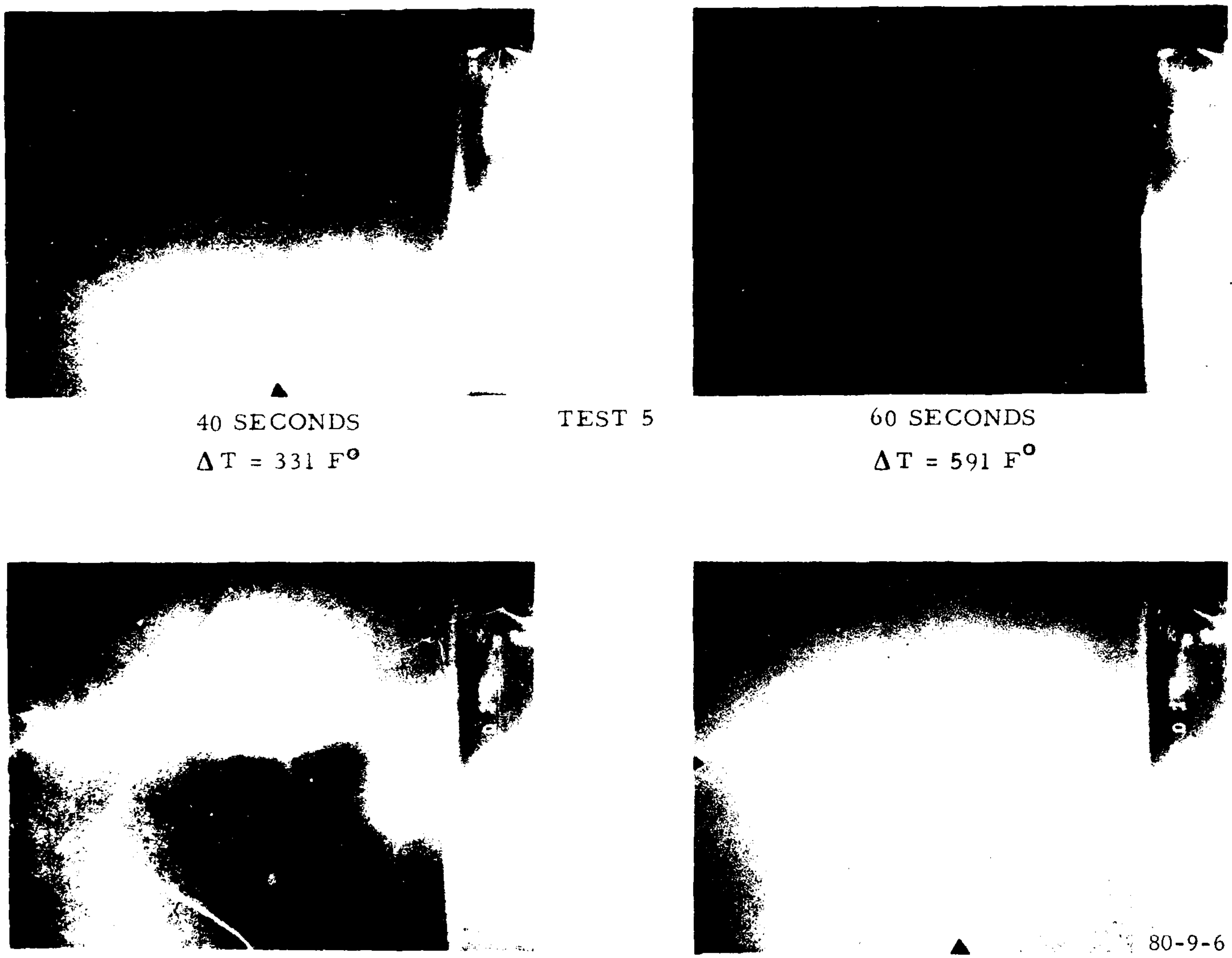


FIGURE 5. INTERIOR VIEWS (TESTS 1 AND 3)



TEST 5 — END WINDOW CLOSED

40 SECONDS
$\Delta T = 331\ F^{o}$

60 SECONDS
$\Delta T = 591\ F^{o}$

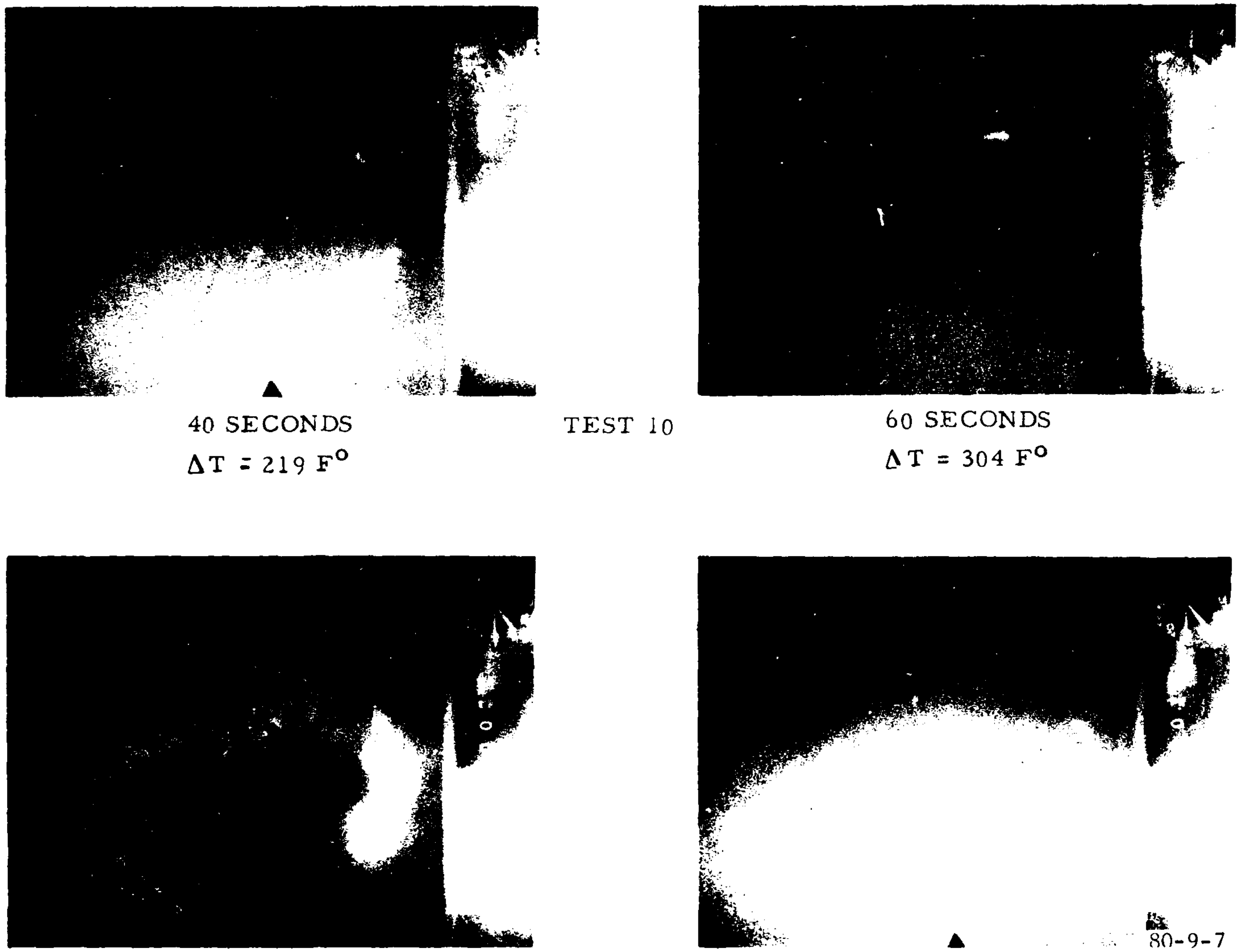
TEST 7 — END WINDOW OPEN

40 SECONDS
$\Delta T = 142\ F^{o}$

60 SECONDS
$\Delta T = 188\ F^{o}$

80-9-6

FIGURE 6. INTERIOR VIEWS (TESTS 5 AND 7)



40 SECONDS
$\Delta T = 219\ F^{o}$

TEST 10

60 SECONDS
$\Delta T = 304\ F^{o}$

END WINDOW

40 SECONDS
$\Delta T = 102\ F^{o}$

TEST 12

60 SECONDS
$\Delta T = 137\ F^{o}$

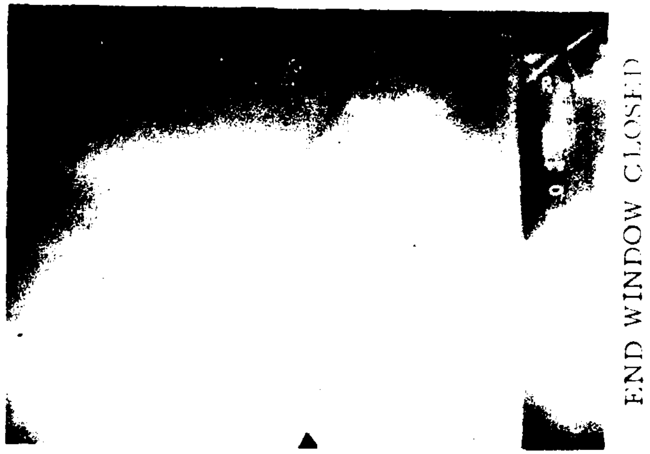
END WINDOW OPEN

80-9-7

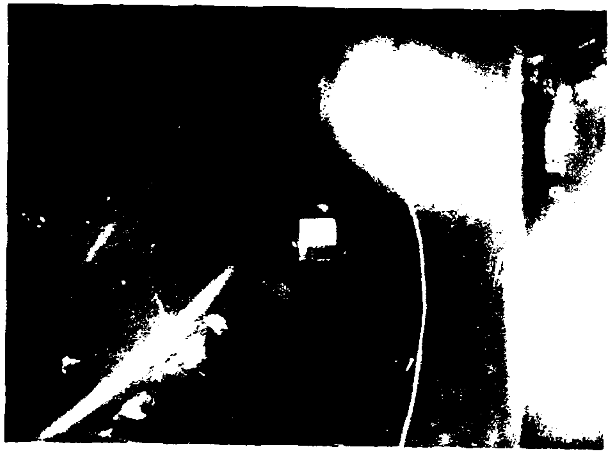
FIGURE 7. INTERIOR VIEWS (TESTS 10 AND 12)

40 SECONDS
$\Delta T = 155\ F^{\circ}$

TEST 14

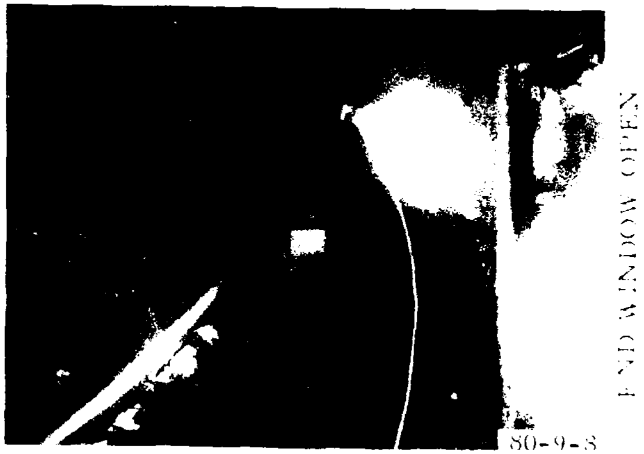


60 SECONDS
$\Delta T = 199\ F^{\circ}$



40 SECONDS
$\Delta T = 42\ F^{\circ}$

TEST 16

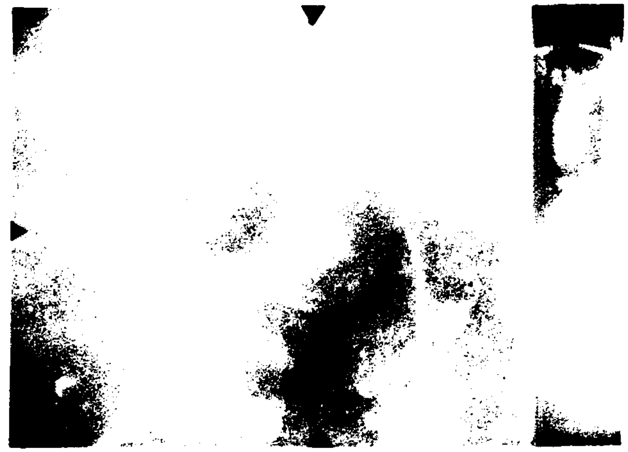


60 SECONDS
$\Delta T = 80\ F^{\circ}$

FIGURE 8. INTERIOR VIEWS (TESTS 14 AND 16)

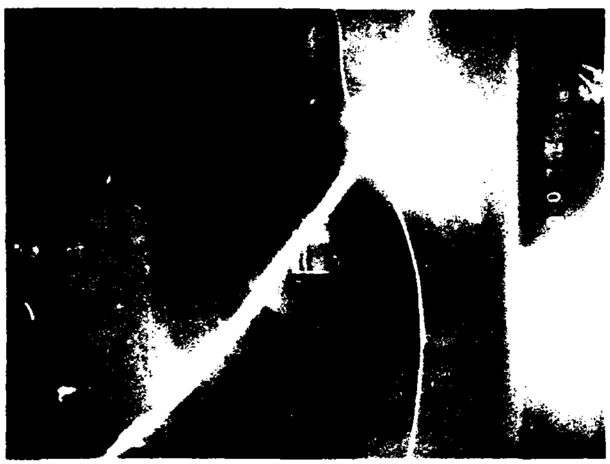
40 SECONDS
$\Delta T = 128\ F^{\circ}$

TEST 18



60 SECONDS
$\Delta T = 180\ F^{\circ}$

END WINDOW CLOSED



40 SECONDS
$\Delta T = 37\ F^{\circ}$

TEST 20

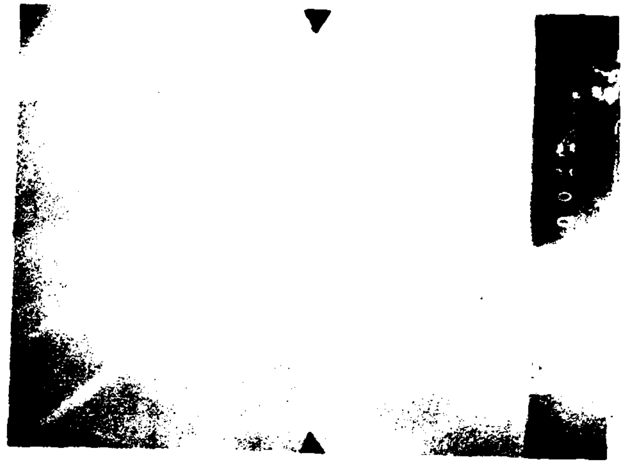
60 SECONDS
$\Delta T = 114\ F^{\circ}$

END WINDOW OPEN

FIGURE 9. INTERIOR VIEWS (TESTS 18 AND 20)

40 SECONDS
$\Delta T = 244$ F°

TEST 22

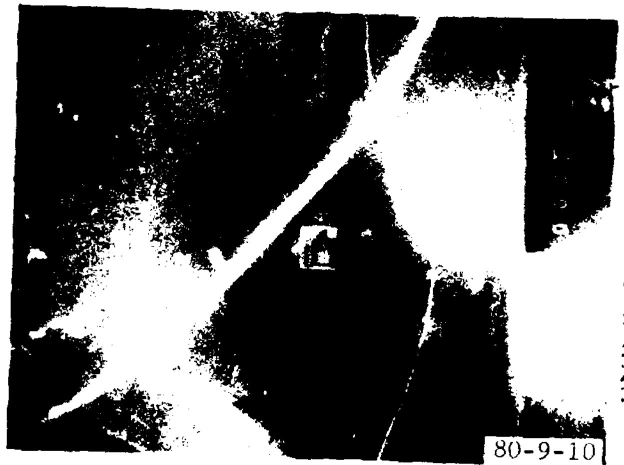


60 SECONDS
$\Delta T = 348$ F°

END WINDOW CLOSED

40 SECONDS
$\Delta T = 34$ F°

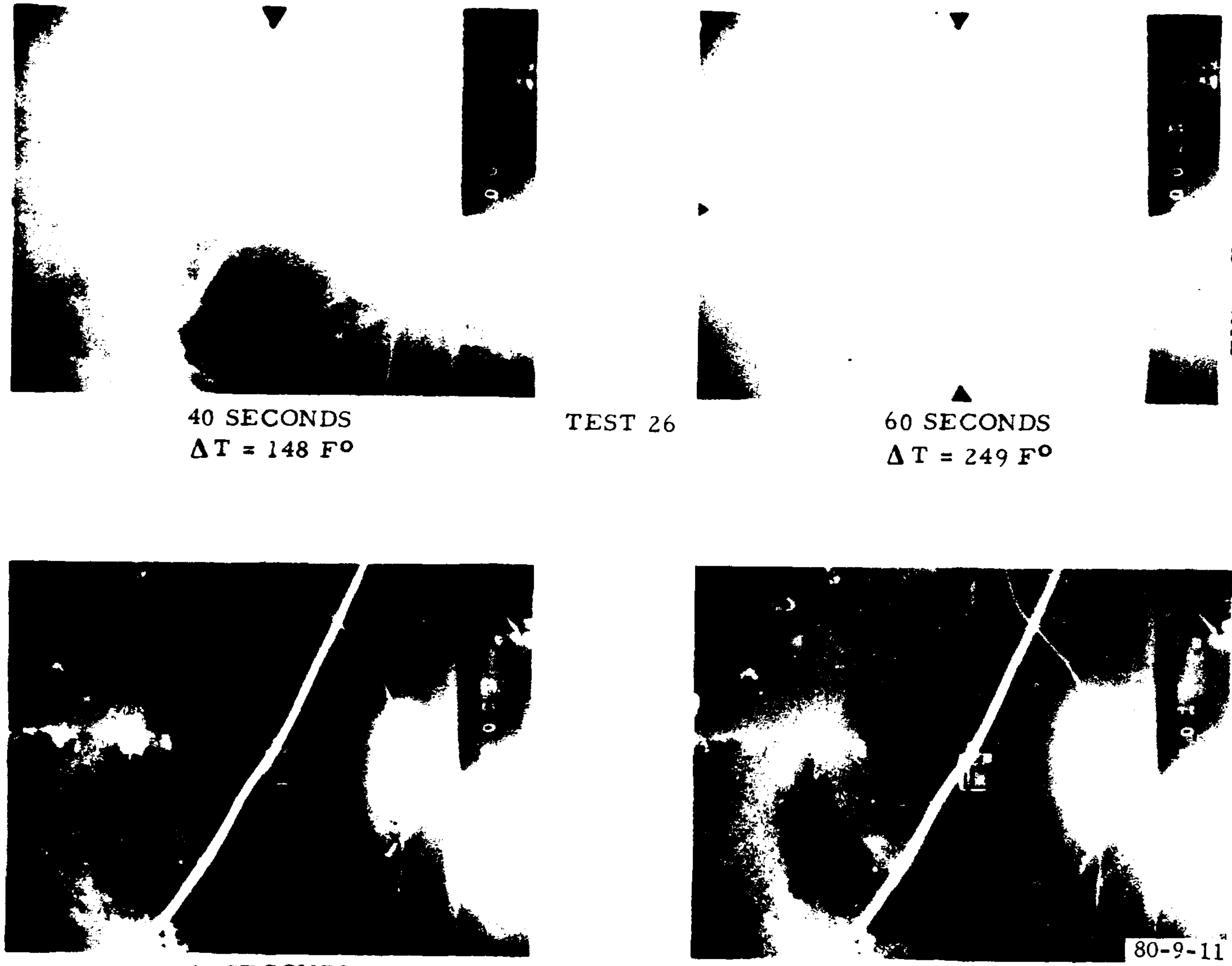
TEST 24



60 SECONDS
$\Delta T = 90$ F°

END WINDOW OPEN

FIGURE 10. INTERIOR VIEWS (TESTS 22 AND 24)



END WINDOW CLOSED

40 SECONDS
$\Delta T = 148$ F°

TEST 26

60 SECONDS
$\Delta T = 249$ F°

END WINDOW OPEN

40 SECONDS
$\Delta T = 41$ F°

TEST 28

60 SECONDS
$\Delta T = 112$ F°

FIGURE 11. INTERIOR VIEWS (TESTS 26 AND 28)

40 SECONDS
$\Delta T = 42$ F°

TEST 30

60 SECONDS
$\Delta T = 151$ F°

END WINDOW CLOSED

40 SECONDS
$\Delta T = 18$ F°

TEST 32

80-9-12

60 SECONDS
$\Delta T = 69$ F°

END WINDOW OPEN

FIGURE 12. INTERIOR VIEWS (TESTS 30 AND 32)

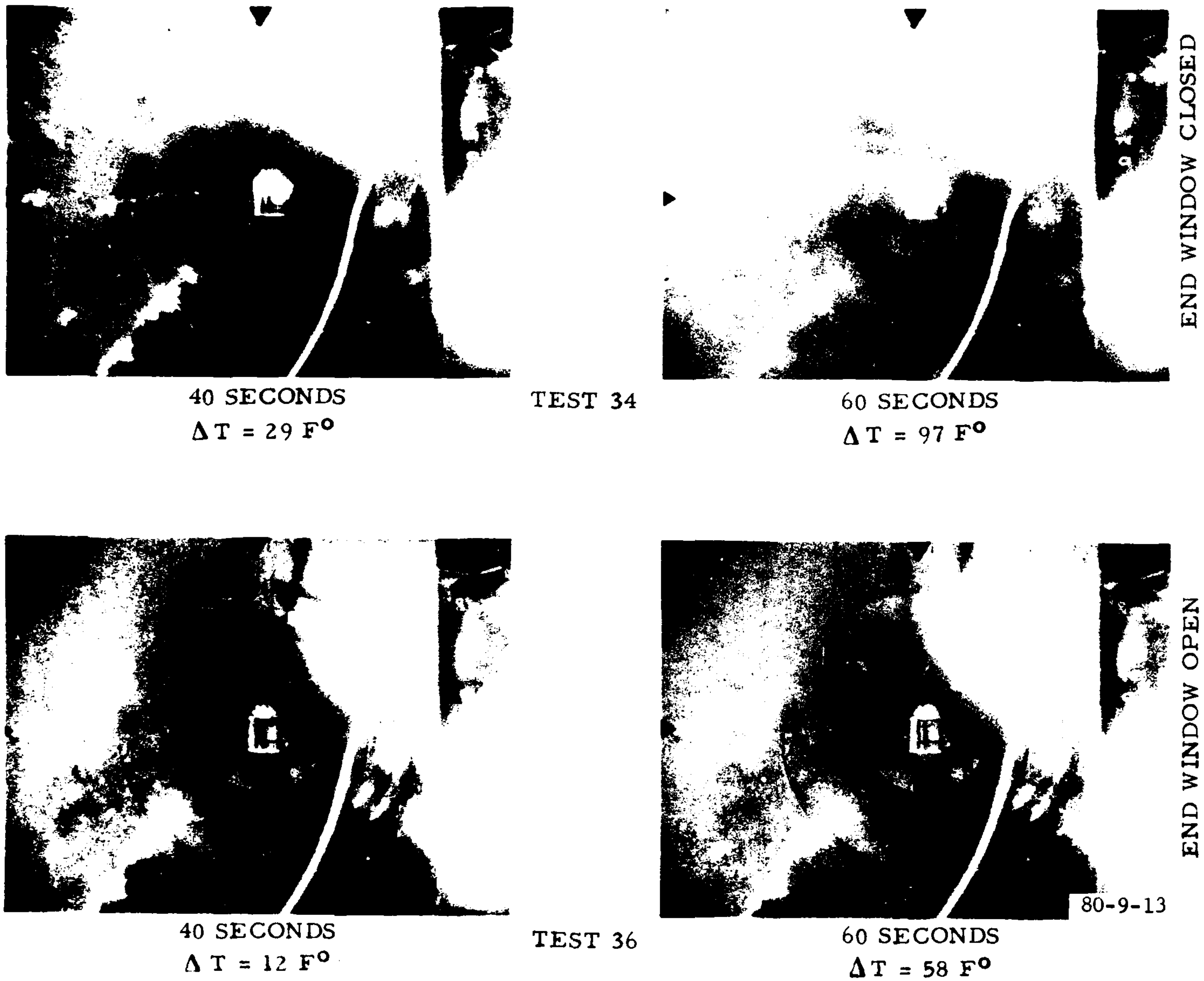


FIGURE 13. INTERIOR VIEWS (TESTS 34 AND 36)

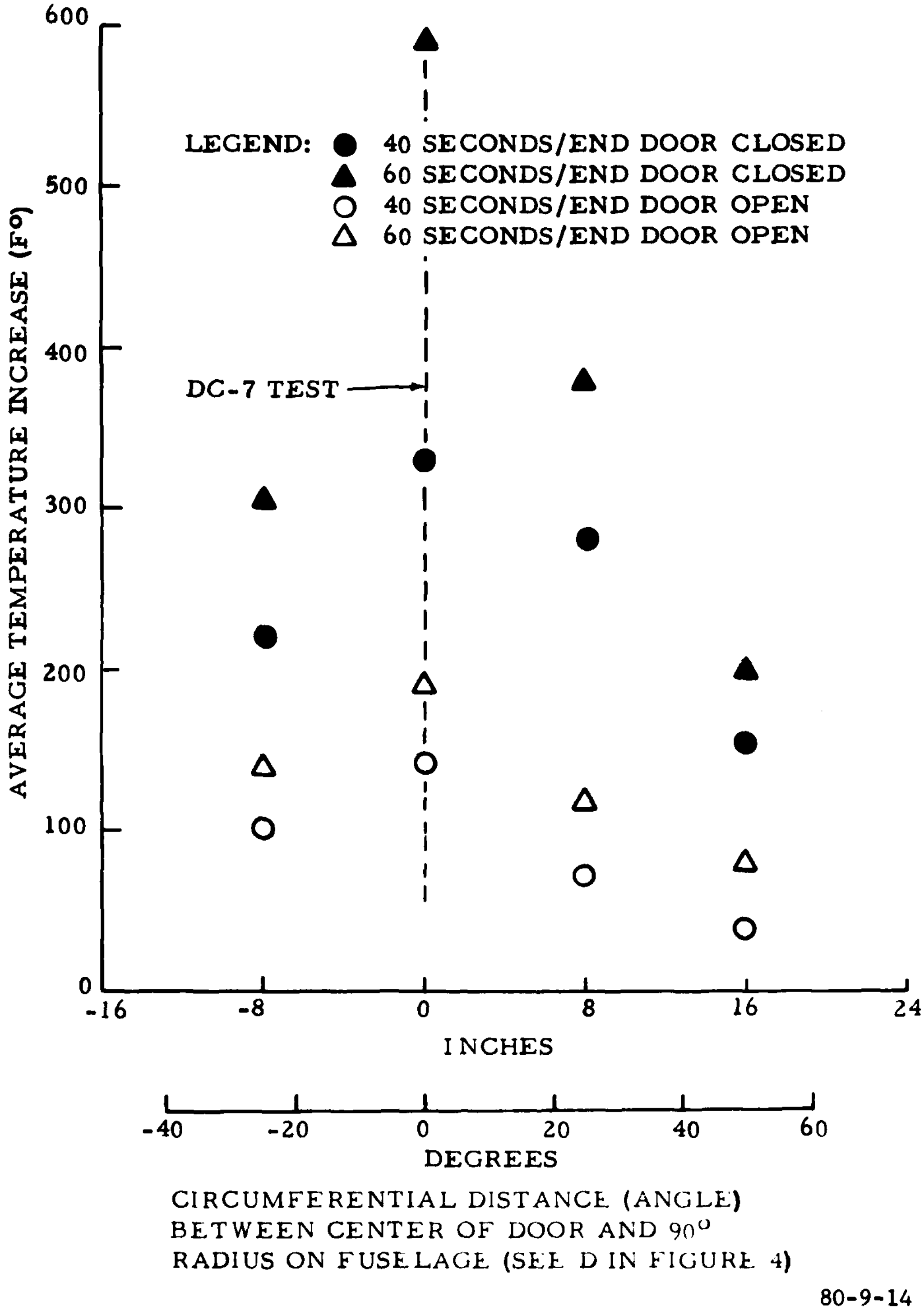


FIGURE 14. TEMPERATURE VERSUS DOOR POSITION (LOW FUEL PAN)

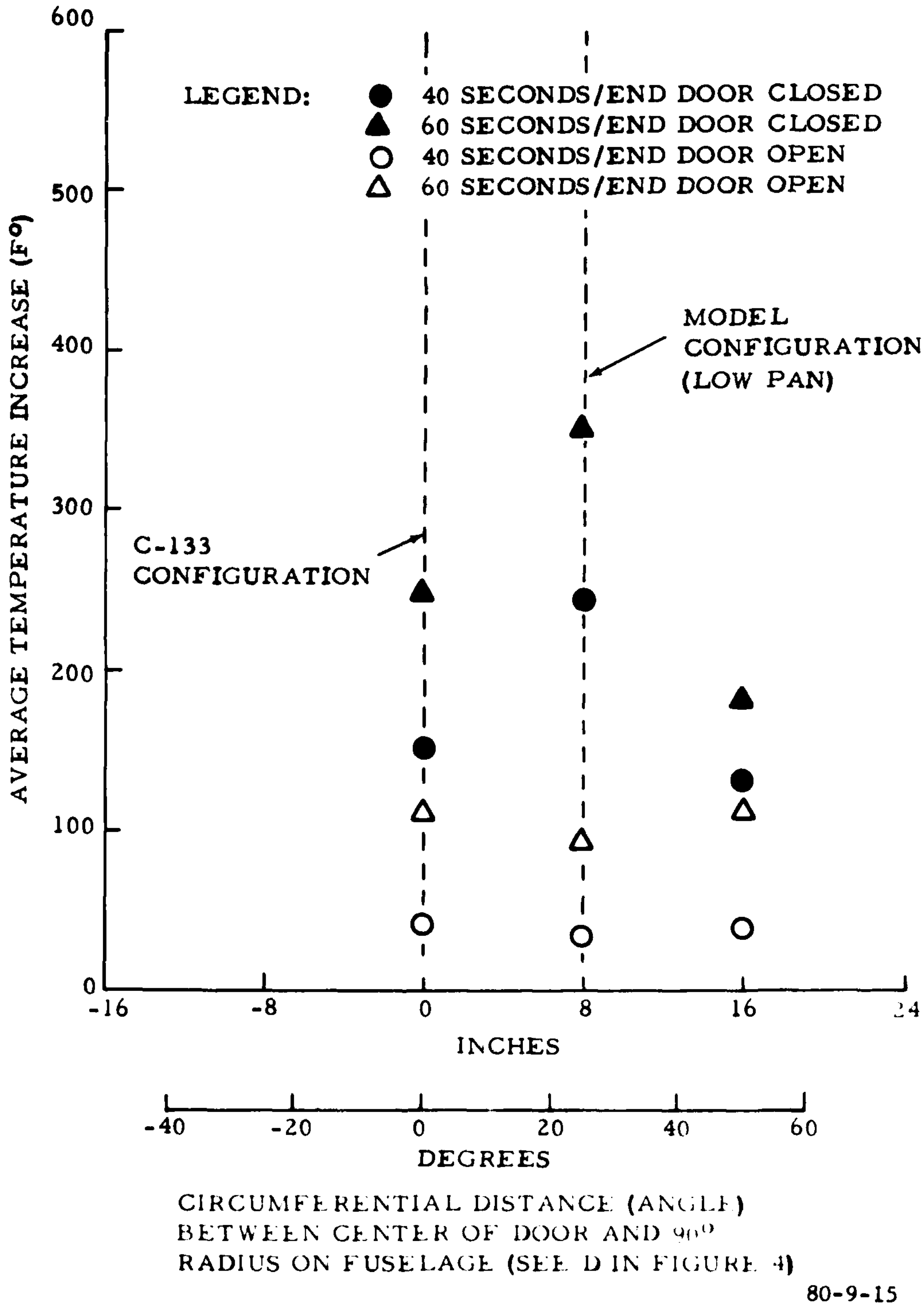


FIGURE 15. TEMPERATURE VERSUS DOOR POSITION (INTERMEDIATE FUEL PAN)

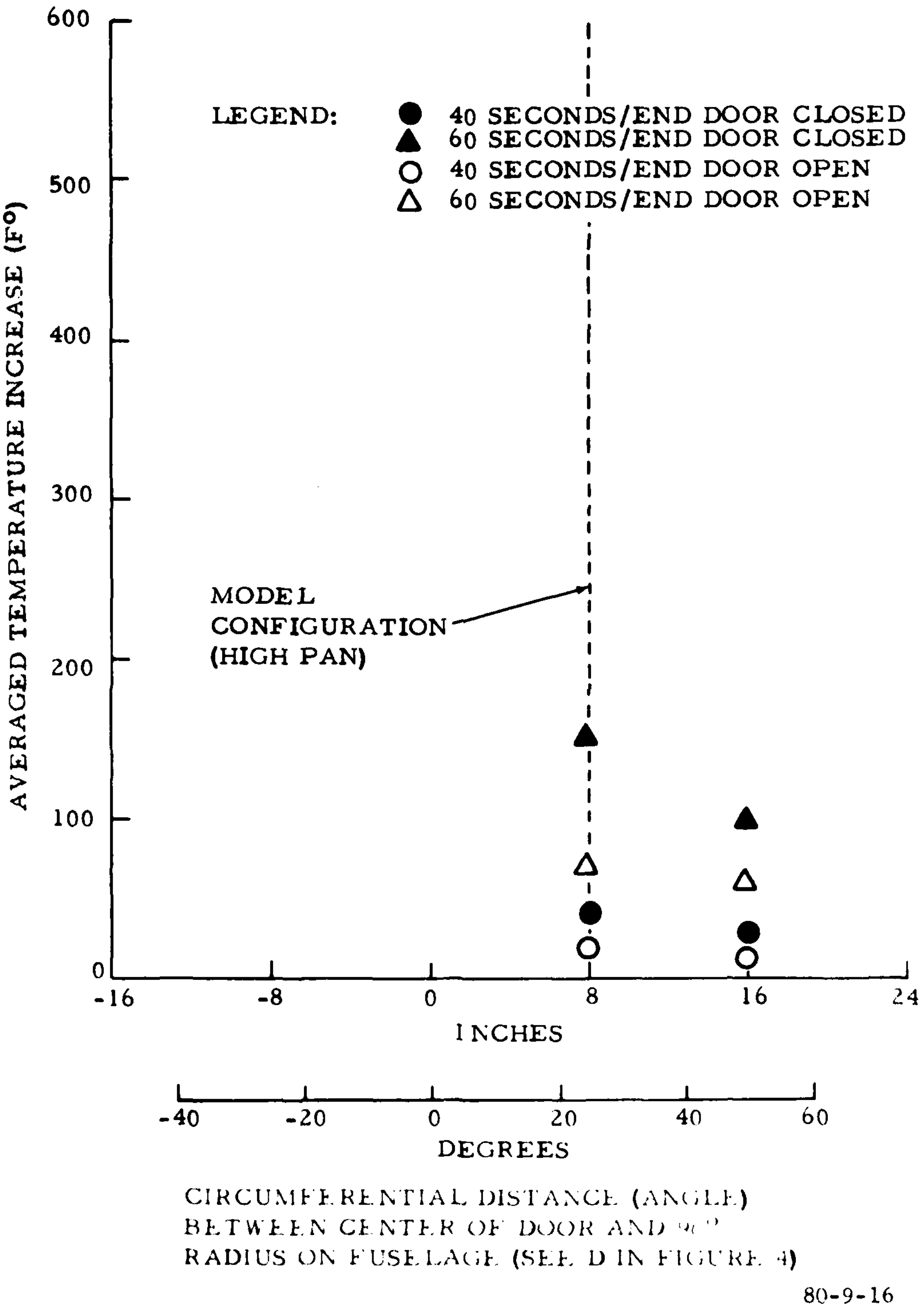


FIGURE 16. TEMPERATURE VERSUS DOOR POSITION (HIGH FUEL PAN)

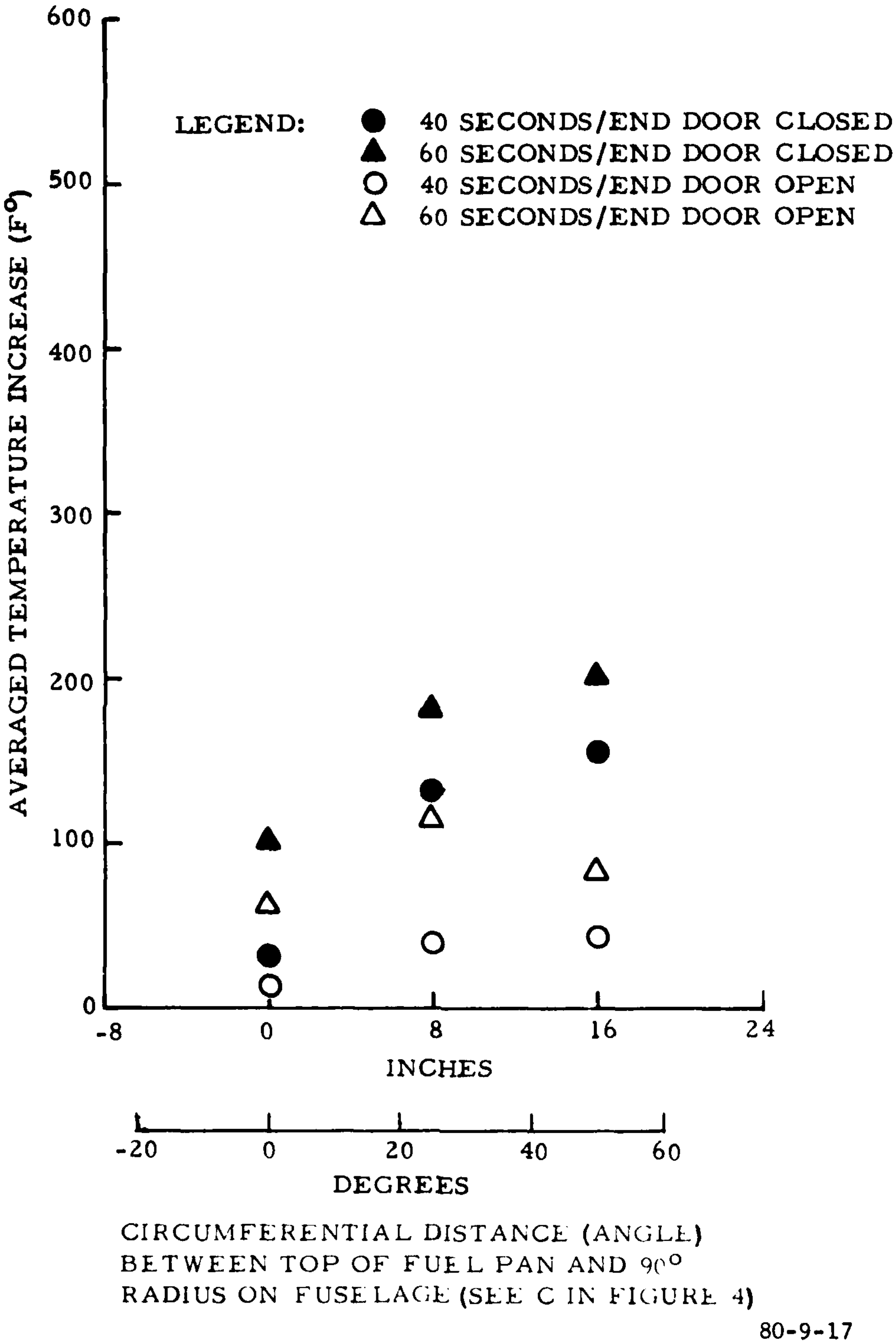


FIGURE 17. TEMPERATURE VERSUS FUEL PAN HEIGHT (HIGH DOOR)

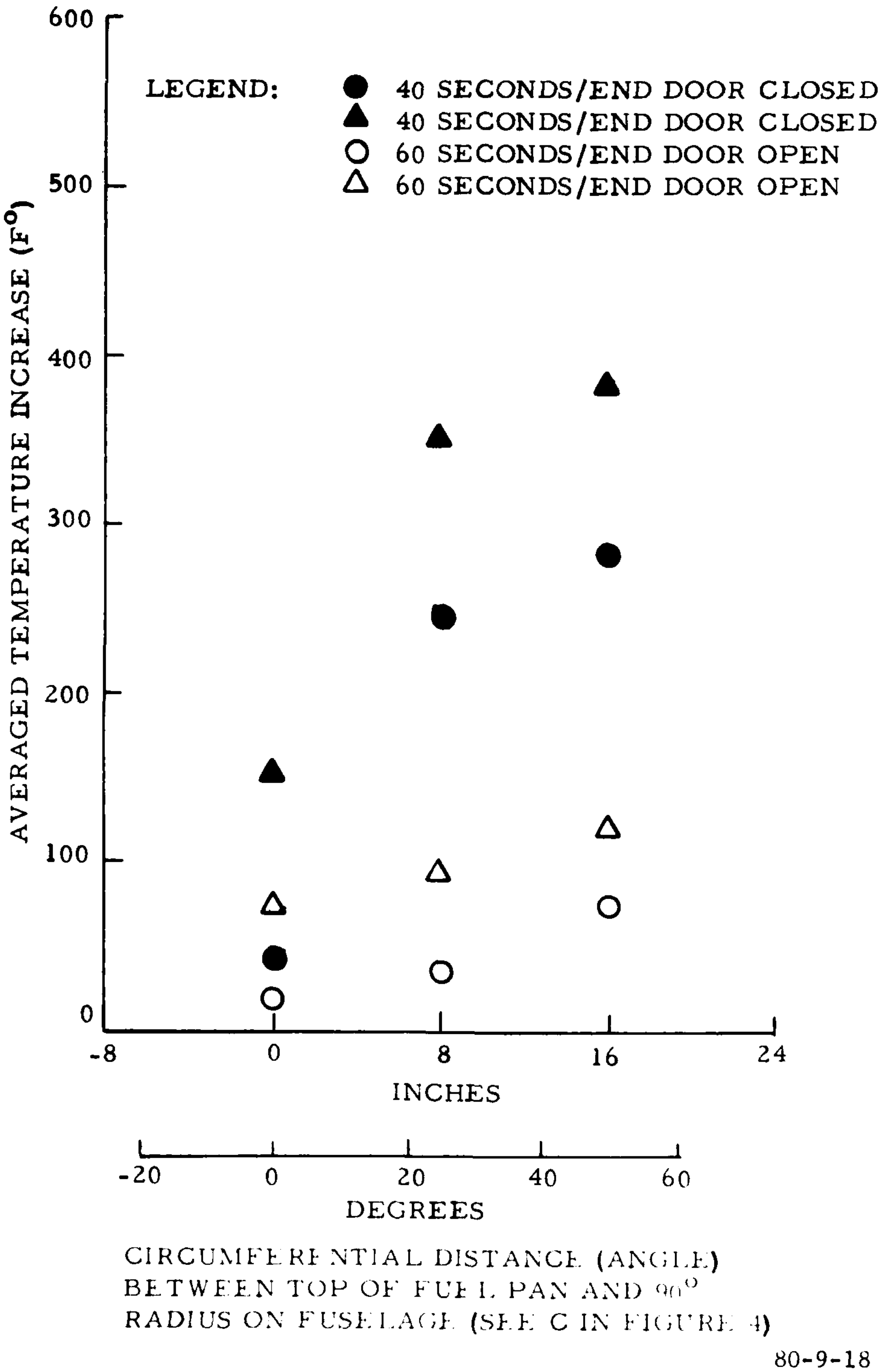


FIGURE 18. TEMPERATURE VERSUS FUEL PAN HEIGHT (INTERMEDIATE DOOR)

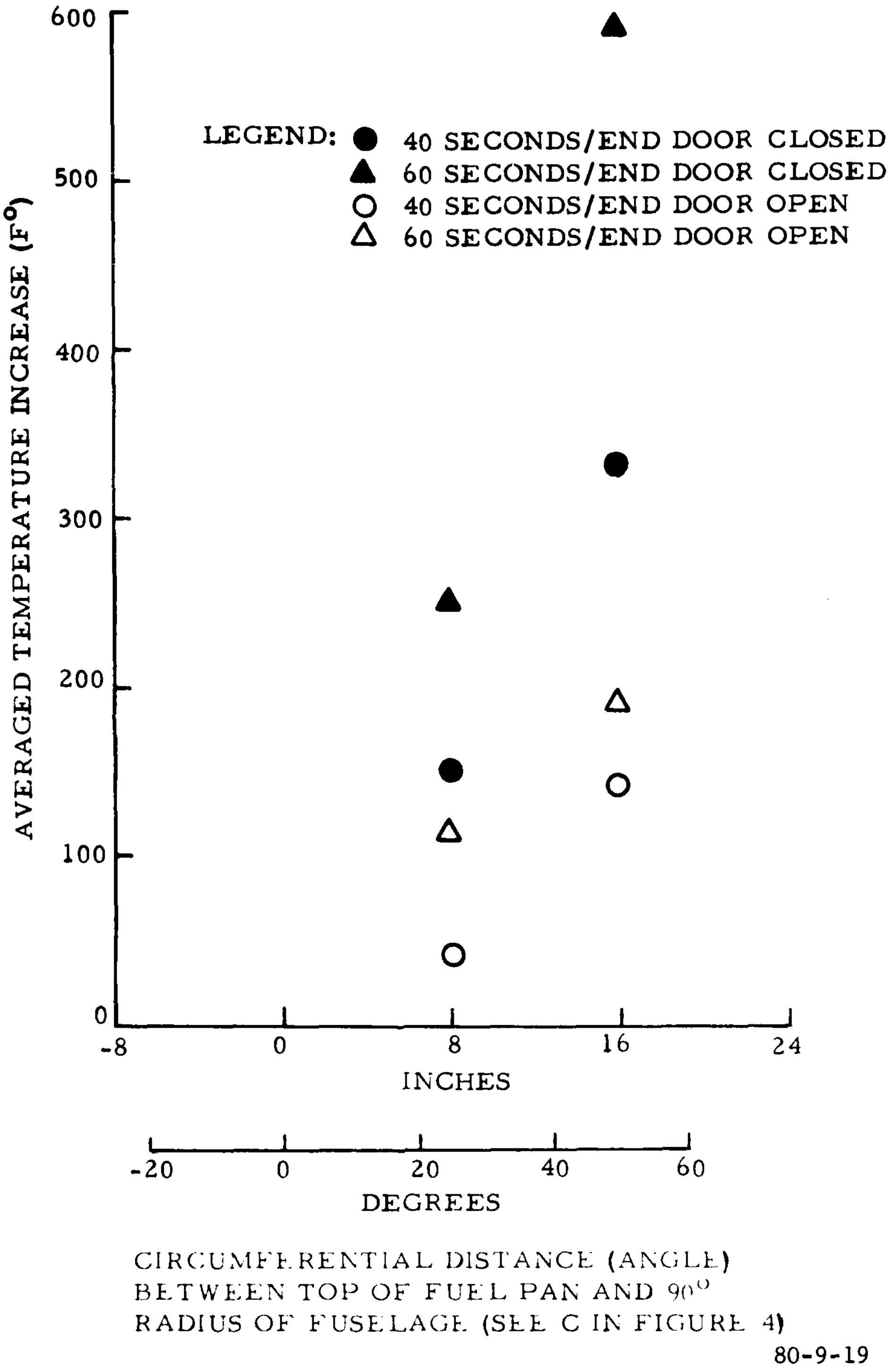


FIGURE 19. TEMPERATURE VERSUS FUEL PAN HEIGHT (DOOR AT 90° RADIUS)

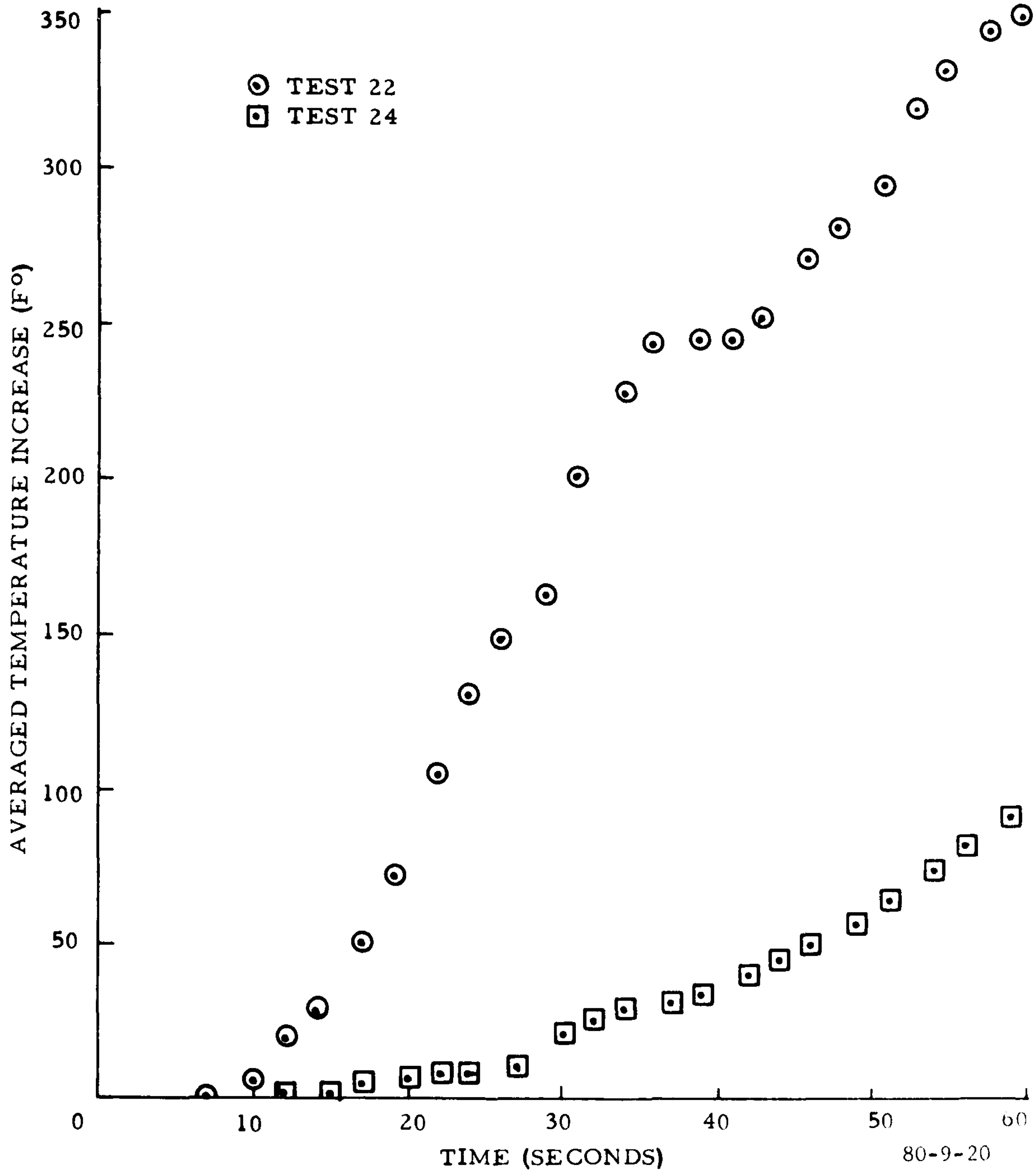


FIGURE 20. TEMPERATURE INCREASE (TESTS 22 AND 24)